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Model:

Long Name: University of California at Los Angeles/NASA Langley Research Center

Acronym: UCLA_LaRC

Model Type: 2D

Numerical Domain:

Domain size in x-direction: 256 km for all simulations

Domain size in z-direction: a1, a2: 20 km;   a3: 12.7 km;   b1, b2: 20 km;   b3: 20 km

Number of grid points in x-direction: 128 for all simulations

Number of grid points in z-direction: a1, a2: 45;   a3: 99;   b1, b2: 45;   b3: 65

Grid size in x-direction: 2000 m for all simulations

Grid size in z-direction:

a1, a2: The grid interval varies with height from 100 m to 486 m at heights below 4396 m and is 500 m above 4396 m.

a3: The grid interval is 75 m below 3975 m and increases gradually with height to 239 m at the top of the model (12.7 km)

b1, b2: Same as a1 and a2.

b3: The grid interval varies with height from 30 m to 102 m at heights below 1904 m and is 500 m above 1904 m.

Time step: 5 seconds for all simulations

Numerical Technique: Please refer to Krueger (1988)

Numerical method: finite-difference; the variables are staggered on a two-dimensional grid.

Advection scheme: The thermodynamical and cloud variables are advected by a second-order accurate scheme (Takacs 1985), while vorticity is advevcted by the Arakawa Jacobian.

Time scheme: The forward scheme is used for the microphysical rates. Takacs scheme is used for cloud-scale advection. The 2nd-order accurate Adams-Bashforth scheme is used for large-scale advective forcing, radiative heating/cooling, hydrometeor sedimentation, and turbulence. The backward scheme is used for some terms in turbulence closure model: decay terms and diffusion terms (mixed).

Dynamic equations: anelastic.

Boundary conditions: At the upper and lower boundaries, we specify zero vertical velocity. At the lateral boundaries, we specify cyclic boundary conditions. The lower boundary is land and ocean for Period A and B, respectively.

Physical Parameterization:

Microphysical parameterization: The cloud microphysical scheme is a two-moment bulk microphysical scheme that predicts mixing ratios and number concentrations of four types of hydrometeors (**Morrison et al. 2005**). Droplet activation is calculated using the Abdul-Razzak and Ghan (2000) scheme coupled to cloud-scale and turbulent scale vertical velocities.

Surface flux parameterization: The ARM-provided domain-averaged surface fluxes of sensible and latent heat are used for the M-PACE simulations. At the lower boundary, the vertical turbulent fluxes of momentum are determined by the surface-layer profiles of the wind velocity according to flux-profile relationships.

Longwave and shortwave radiation parameterization: The radiative transfer (RT) scheme has six and twelve spectral bands for solar and thermal IR regions, respectively (Fu and Liou 1993, Fu 1996, Fu et al. 1998). As inputs to the RT scheme, the effective radius of cloud droplet and generalized effective diameter of ice crystals are calculated from the hydrometeor size spectral which are predicted by the microphysical scheme. The surface spectral albedo is determined from the observed broadband albedo combined with the curve of spectral albedo over snow for Period A, while the ocean surface spectral albedo is determined using the parameterization of Jin et al (2004) for Period B.

Turbulence closure scheme: We use a 3rd-order turbulence closure (Krueger 1988).

Documentation:

Abdul-Razzak, H., and S. J. Ghan, 2000: A parameterization of aerosol activation, 2. Multiple aerosol types. *J. Geophys. Res.*, **105**, 6837-6844.

Fu, Q., 1996: An accurate parameterization of the solar radiative properties of cirrus clouds for climate models. *J. Climate.*, **9**, 2058-2082.

Fu, Q., and K. N. Liou, 1993: Parameterization of the radiative properties of clouds. *J. Atmos. Sci.*, **50**, 2008-2025.

Fu, Q., P. Yang, and W. B. Sun, 1998: An accurate parameterization of the infrared radiative properties of cirrus clouds for climate models. J. Climate., **11**, 2223-2237.

Jin, Z., T. Charlock, W. Smith Jr., and K. Rutledge, 2004: A parameterization of ocean surface albedo. *Geophys. Res. Let.*, **31**, L22301, doi:10.1029/2004GL021180.

Krueger, S., 1988: Numerical simulation of tropical cumulus clouds and their interaction with the subcloud layer. *J. Atmos. Sci.*, **45**, 2221-2250.

Morrison, H., J. A. Curry, and V. I. Khvorostyanov, 2005: A new double-moment microphysics parameterization for application in cloud and climate models. Part I: Description. *J. Atmos. Sci.*, **62**, 1665-1677.

Takacs, L. L., 1985: A two-step scheme for the advection equation with minimized dissipation and dispersion errors. *Mon. Wea. Rev.*, **113**, 1050-1065.